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THE FOOD OF THE DARTERS.

BY S. A. FORBES.

WHAT the humming-birds are in our avifauna, the "darters" are among our fresh-water fishes. Minute, agile, beautiful, delighting in the clear, swift waters of rocky streams, no group of fishes is more interesting to the collector; and in the present state of their classification, none will better repay his study. Notwithstanding their trivial size, they do not seem to be *dwarfed* so much as *concentrated* fishes—each carrying in its little body all the activity, spirit, grace, complexity of detail and perfection of finish to be found in a perch or a "wall-eyed pike."

To the entertaining and instructive account of the sub-family given by Jordan and Copeland in former numbers of the NATURALIST,[1] I propose to add a few notes on their food, based upon a study of the contents of seventy stomachs, and to point out some of the correlations between structure and habit, with a view to accounting for the origin of the group.

These seventy specimens represented fifteen species, collected in all parts of Illinois, in several months of four successive years. They indicate much more than their number would imply, since from those collected at each time and place, as many were commonly studied as were necessary to give a full idea of the food of the species then and there. The different individuals from the same date and locality usually agreed so closely in food, that the study of from two to five gave all the facts obtainable from several times as many. The data here given, therefore, really exhibit the food of the family at different seasons in twenty-nine localities within the State.

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[1] "Johnny Darters." By D. S. Jordan and H. E. Copeland. AM. NAT., Vol. X, No. 6, June, 1876, pp. 335–341.

"The Sand Darter." By D. S. Jordan and H. E. Copeland. AM. NAT., Vol. XI, No. 2, Feb., 1877, pp. 86–88.

The genus *Pleurolepis* is comparatively rare in Illinois, as there are few of the sandy streams in the State, which it inhabits. Seven individuals were examined—four of *P. pellucidus* and three of *P. asprellus*. The food of these specimens was remarkably uniform—the only elements found being the larvæ of small diptera and Ephemerids. Eighty-one per cent. of the food of all consisted of the larva of Chironomus,[1]—a small, gnat-like insect,—twelve per cent. of the larva of other small diptera, and the remaining seven per cent. of Ephemerid larvæ (May flies).

Twelve specimens of the genus *Alvordius* were studied—seven of *maculatus* and five of *phoxocephalus*.[2] These represented five different localities and dates. This is a larger species than the preceding, and to this fact is probably due the predominance (seventy-five per cent.) in its food of the larvæ and pupæ of May flies (Ephemeridæ). These included four per cent. of the larvæ of *Palingenia bilineata* Say, one of the largest Ephemerids in our streams. The remaining kinds were larvæ of dragon flies (Agrionini), four per cent.; larvæ of Chironomus, seven per cent., and *Corixa tumida* Uhl., thirteen per cent.

The genus *Boleosoma*, regarded by Dr. Jordan as the typical darter, was represented by twelve specimens from eight localities—nine of *maculatum*, two of *olmstedi* and one of *camurum*.[3] These specimens show but slight food differences from other darters of similar size; the only notable variation being the appearance of fifteen per cent. of case-worms (larvæ of Phryganeidæ). Sixty-six per cent. of the food was Chironomus larvæ, seven per cent. larvæ of other minute diptera (including Simulium), and the remaining eight per cent. was larvæ of small Ephemerids.

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[1] The larvæ of Chironomus are among the most important elements of fish food in our waters, appearing in abundance in the stomachs of the young of a great variety of species. They have been too little studied in this country to allow specific determination.

[2] The classification used in this paper is that of the second edition of Jordan's Manual of Vertebrates.

[3] *Boleosoma maculatum* and *B. olmstedi* should undoubtedly be united. Specimens in the laboratory collection present the extremes of both forms, together with numerous intermediate stages of each character used to distinguish them.

This whole group exhibits a surprising variability, perhaps due to its comparatively recent origin.

I studied the food of two specimens of *Pœcilichthys variatus*, four of *P. spectabilis* and two of *P. asprigenis*—making eight of the genus, representing six localities. Fifty-eight per cent. of small larvæ of diptera (forty-nine per cent. of Chironomus), thirty-two per cent. of larvæ and pupæ of small Ephemerids, and ten per cent. of case-worms made up the entire bill of fare.

Percina caprodes, the largest of the group, departs from all the foregoing species by the introduction of crustacean food—thirty per cent. of Entomostraca and three per cent. the smallest of our Amphipoda, *Allorchestes dentata* (Smith) Faxon. Most of the Entomostraca were *Cladocera*, including Daphnia, Eurycercus and Daphnella.[1]

Here occurred the only instance of molluscan food in the group. One specimen had taken a few individuals of *Ancylus rivularis* Say. Reduced ratios of Chironomus and Ephemerid larvæ, and a few *Corixa tumida* complete the list.

Of *Nanostoma zonale*, less common than the others, but two individuals were examined, and these had eaten nothing but larvæ of small diptera, including sixty-five per cent. of Chironomus.

Six specimens of *Etheostoma flabellare* var. *lineolata*, from four localities, had eaten sixty-one per cent. of Chironomus larvæ, twenty-seven per cent. larvæ of small Ephemerids, and twelve per cent. of Copepoda (Cyclops).

Boleichthys elegans, found only in the southern part of the State (three specimens examined), had eaten only dipterous larvæ (thirty-seven per cent.) and Ephemerid larvæ (sixty-three per cent.). This is a larger, heavier species than most of the others, and, therefore, like Alvordius, prefers Ephemerids to gnats.

Last and least comes *Microperca punctulata*, represented by nine specimens from four localities in Northern Illinois. This smallest of the darters shares with Percina, the largest, the peculiarity of crustacean food, which made up sixty-four per cent. of the total. The principal kinds were Cyclops, Chydorus, young

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[1] Daphnella was found in a Percina from the Calumet river, at South Chicago, but not in condition to permit the determination of the species.

Gammarus fasciatus Say, and young *Crangonyx gracilis* Smith. The remaining elements were Chironomus larvæ (thirty-four per cent.) and a trace of Ephemerids (two per cent.).

It will be seen that the family, taken as a whole, divides into two sections, distinguished by the presence or absence of crustacean food. This is easily explained by the fact that Percina and Microperca range much more freely than the other genera—being frequently found among weeds and Algæ in comparatively slow water with muddy bottom, while the others are rather closely confined to swift and rocky shallows.

In discussing the food of the whole group, taken as a unit, it may best be compared with the food of the young of other percoids. It is thus seen to be remarkable for the predominance of the larvæ of Chironomus and small Ephemeridæ—the former of these comprising forty-four per cent. and the latter, twenty-three per cent. of the whole food of the seventy specimens. In young black bass *(Micropterus pallidus)* on the other hand, the averages of nine specimens, ranging from five-eighths inch to one and a half inches in length, were, in general terms, as follows: Cladocera forty-two per cent., Copepoda seven per cent., young fishes twenty per cent., Corixa and young Notonecta twenty-nine per cent., and larval Chironomus only two per cent. The search for the cause of this difference leads naturally to an examination of the whole economy of these little fishes, and opens up the question of their origin as a group.

The close relation of the Etheostomatinæ to the Percidæ proper, requires us to believe that the two groups have but recently diverged, if, indeed, they are yet distinctly separate.

We must inquire, therefore, into the causes which have operated upon a group of percoids to limit their range to such apparently unfavorable situations, to diminish their size, to develop unduly the paired fins and reduce the air-bladder, to remove the scales of several species more or less completely from the head, breast, neck and ventral region, and to restrict their food chiefly to the few forms mentioned above.

No species can long maintain itself anywhere which cannot, in some way, find a sufficient supply of food, and also protect itself against its enemies. In the contest with its enemies it may acquire defensive structures or powers of escape sufficient for its protection, or a reproductive capacity which will compensate for large losses, or it may become adapted to some place of refuge where other fishes will not follow. What better refuge could a harrassed fish desire than the hiding places among stones in the shallows of a stream, where the water dashes ceaselessly by with a swiftness few fish can stem? And if, at the same time, the refugee develops a swimming power which enables it to dart like a flash against the strongest current, its safety would seem to be ensured. But what food could it find in such a place? Let us turn over the stones in such a stream, sweeping the roiled water at the same time with a small cloth net, and we shall find—larvæ of Chironomus and small Ephemerids and other such prey, and little else; food too minute and difficult of access to support a large fish, but answering very well if our immigrant *can keep down his size.* Here the principles of natural selection assert their power. The limited supply of food early arrests the growth of the young; while every fish which passes the allowable maximum is forced for food to brave the dangers of the deeper waters where the chances are that it falls a prey. On the other hand, the smaller the size of those which escape this alternative, the less likely will they be to attract the appetite of the small gar or other guerilla which may occasionally raid their retreat, and the more easily will they slip about under stones in search of their microscopic game.[1]

Like other fishes, the darters must have their periods of repose, all the more urgent because of the constant struggle with the swift current which their habitat imposes. Shut out from the deep still pools and slow eddies where the larger species float suspended in mid stream, they are forced to spend their leisure on or beneath the bottom of the stream, resting on their extended pectorals and anal, or wholly buried in the sand. Possibly this fact is correlated with the absence or rudimentary condition of the air-bladder; as it is a rule with many exceptions—but still, probably, a rule—that this organ is wanting in fishes which live chiefly at the bottom.

Doubtless the search for food has much to do with this selection of a habitat. I have found that the young of nearly all species of our fresh-water fishes are competitors for food, feeding almost entirely on entomostraca and the larvæ of minute diptera.[1] As a tree sends out its roots in all directions in search of nourishment, so each of the larger divisions of animals extends its various groups into every place where available food occurs, each group becoming adapted to the special features of its situation. Given this supply of certain kinds of food, nearly inaccessible to the ordinary fish, it is to be expected that some fishes would become especially fitted to its utilization. Thus the Etheostomatinæ as a group are explained, in a word, by the hypothesis of the progressive adaptation of the young of certain Percidæ to a peculiar place of refuge and a peculiarly situated food supply.

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[1] In Boleosoma, which is normally scaled in front of the dorsal fin, we often find the skin of this region bare in large specimens, and showing evident signs of rubbing.

Perhaps we may, without violence, call these the mountaineers among fishes. Forced from the populous and fertile valleys of the river beds and lake bottoms, they have taken refuge from their enemies in the rocky highlands where the free waters play in ceaseless torrents, and there they have wrested from stubborn nature a meagre living. Although diminished in size by their continual struggle with the elements, they have developed an activity and hardihood, a vigor of life and glow of high color almost unknown among the easier livers of the lower lands.

The appended table will facilitate a comparison of the records of the different genera. The percentages were obtained by estimating carefully the ratios of each element of the food of each individual, and averaging these ratios for all the individuals of a species:

DETAILS OF THE FOOD OF THE ETHEOSTOMATINÆ.

	Pleurolepis.	Alvordius.	Boleosoma.	Pœcilichthys.	Percina.	Nanostoma.	Etheostoma.	Boleichthys.	Microperca.
Number of specimens.....	7	12	12	8	11	2	6	3	9
I. MOLLUSCA........					01				
Ancyius rivularis Say.....					01				
II. INSECTA	100	99	96	100	65	100	88	100	36
1. Diptera	93	07	73	58	43	100	61	37	34
Undetermined larvæ ...	12	01	07	09	02	35		10	
Chironomus larvæ	81	06	66	49	41	65	61	27	34
" pupæ.....									
2. Hemiptera............		13			05				
Corixa...............		13			05				
Undetermined.......					03				
Larvæ.............		07			02				
C. tumida Uhl.......		06							

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[1] The Catostom[at]idæ (suckers) are an exception to this rule, feeding when young chiefly on Algæ and Protozoa.

	Pleurolepis.	Alvordius.	Boleosoma.	Pœcilichthys.	Percina.	Nanostoma.	Etheostoma.	Boleichthys.	Microperca.
3. Neuroptera	07	79	23	42	17		27	63	02
Ephemeridæ	07	75	08	32	09		27	63	02
Pupæ		08		14					
Larvæ	07	63	08	18	09		27	63	02
Palingenia		04							
Agrionini (pupæ)		04							
Phryganeidæ (larvæ)			15	10	08				
III. CRUSTACEA		01	04		33		12		64
1. Amphipoda					03				12
Gammarus, yg.									06
Crangonyx "									06
Allorchestes dentata Sm.					03				
2. Ostracoda					01				06
Cyprididæ					01				06
Undetermined					01				
Cypris									
3. Cladocera					24				27
Undetermined					05				
Daphniidæ					06				
Daphnia					07				
Sididæ					05				
Daphnella					05				
Lynceidæ					01				03
Chydorus									24
Eurycercus					01				
4. Copepoda		01	04		05		12		19
Cyclops		01	04		05		12		19
Confervoid Algæ					01				

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ON THE FORMER EXTENT OF THE TRIASSIC FORMATION OF THE ATLANTIC STATES.[1]

BY ISRAEL C. RUSSELL.

NEARLY two years since I read a paper before the New York Academy of Sciences, on the Physical History of the Triassic Formation in New Jersey and the Connecticut valley,[2] in which many reasons were given for concluding that the Triassic rocks of these two regions were detached portions of one estuary formation.

As several papers have been published relating to the Triassic rocks of the Atlantic States since my essay was written, increasing our knowledge of the subject, and as my interpretation of the geological records has not been accepted by some geologists, I

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[1] Read before the New York Academy of Sciences, March 22, 1880.

[2] Annals of the N. Y. Acad. of Sci., Vol. 1, No. 8 (1878), pp. 220–254.